S. Eidelman and Particle Data Group
Phys. Lett. B 592 862 (04)

n MEAN LIFE

We now compile only direct measurements of the lifetime, not those inferred from decay correlation measurements. For the average, we only use measurements with an error less than 10 s.

Limits on lifetimes for *bound* neutrons are given in the section "p PARTIAL MEAN LIVES."

For an early review, see EROZOLIMSKII 89 and papers that follow it in an issue of NIM devoted to the "Proceedings of the International Workshop on Fundamental Physics with Slow Neutrons" (Grenoble 1989). For later reviews and/or commentary, see FREEDMAN 90, SCHRECKENBACH 92, and PENDLEBURY 93.

VALUE (s)	*DOCUMENT ID*	*TECN*	*COMMENT*
885.7± 0.8 OUR AVERAGE			
886.8± 1.2± 3.2	DEWEY 03	CNTR	In-beam n, p trap
885.4± 0.9± 0.4	ARZUMANOV 00	CNTR	UCN double bottle
889.2± 3.0± 3.8	BYRNE 96	CNTR	Penning trap
882.6± 2.7	[9] MAMPE 93	CNTR	Gravitational trap
888.4± 3.1± 1.1	NESVIZHEV... 92	CNTR	Gravitational trap
887.6± 3.0	MAMPE 89	CNTR	Gravitational trap
891 ± 9	SPIVAK 88	CNTR	Beam
• • • We do not use the following data for averages, fits, limits, etc. • • •			
888.4± 2.9	ALFIMENKOV 90	CNTR	See NESVIZHEVSKII 92
893.6± 3.8± 3.7	BYRNE 90	CNTR	See BYRNE 96
878 ±27 ±14	KOSSAKOW... 89	TPC	Pulsed beam
877 ±10	PAUL 89	CNTR	Storage ring
876 ±10 ±19	LAST 88	SPEC	Pulsed beam
903 ±13	KOSVINTSEV 86	CNTR	Gravitational trap
937 ±18	[10] BYRNE 80	CNTR	
875 ±95	KOSVINTSEV 80	CNTR	
881 ± 8	BONDAREN... 78	CNTR	See SPIVAK 88
918 ±14	CHRISTENSEN72	CNTR	

[9] IGNATOVICH 95 calls into question some of the corrections and averaging procedures used by MAMPE 93. The response, BONDARENKO 96, denies the validity of the criticisms.

[10] This measurement has been withdrawn (J. Byrne, private communication, 1990).

n MAGNETIC MOMENT

See the "Note on Baryon Magnetic Moments" in the Λ Listings.

VALUE (μ_N)	*DOCUMENT ID*	*TECN*	*COMMENT*
−1.91304273±0.00000045	MOHR 04	RVUE	2002 CODATA value
• • • We do not use the following data for averages, fits, limits, etc. • • •			
−1.91304272±0.00000045	MOHR 99	RVUE	1998 CODATA value
−1.91304275±0.00000045	COHEN 87	RVUE	1986 CODATA value
−1.91304277±0.00000048	[11] GREENE 82	MRS	

[11] GREENE 82 measures the moment to be $(1.04187564 \pm 0.00000026) \times 10^{-3}$ Bohr magnetons. The value above is obtained by multiplying this by $m_p/m_e = 1836.152701 \pm 0.000037$ (the 1986 CODATA value from COHEN 87).

n ELECTRIC DIPOLE MOMENT

A nonzero value is forbidden by both T invariance and P invariance. A number of early results have been omitted. See RAMSEY 90 and GOLUB 94 for reviews.

VALUE (10^{-25} ecm)	*CL%*	*DOCUMENT ID*	*TECN*	*COMMENT*
< 0.63	90	[12] HARRIS 99	MRS	$d = (-0.1 \pm 0.36) \times 10^{-25}$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 0.97	90	ALTAREV 96	MRS	$(+0.26 \pm 0.40 \pm 0.16) \times 10^{-25}$
< 1.1	95	ALTAREV 92	MRS	See ALTAREV 96
< 1.2	95	SMITH 90	MRS	See HARRIS 99
< 2.6	95	ALTAREV 86	MRS	$d = (-1.4 \pm 0.6) \times 10^{-25}$
0.3 ±4.8		PENDLEBURY 84	MRS	Ultracold neutrons
< 6	90	ALTAREV 81	MRS	$d = (2.1 \pm 2.4) \times 10^{-25}$
<16	90	ALTAREV 79	MRS	$d = (4.0 \pm 7.5) \times 10^{-25}$

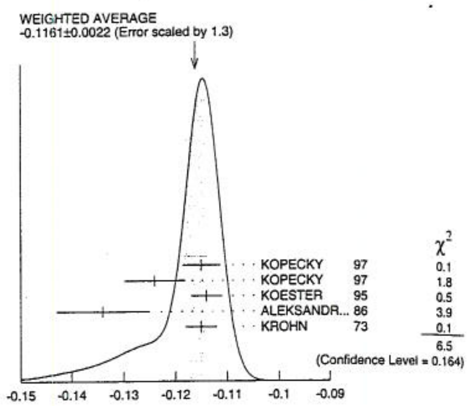
[12] This HARRIS 99 result includes the result of SMITH 90. However, the averaging of the results of these two experiments has been criticized by LAMOREAUX 00.

n MEAN-SQUARE CHARGE RADIUS

The mean-square charge radius of the neutron, $\langle r_n^2 \rangle$, is related to the neutron-electron scattering length b_{ne} by $\langle r_n^2 \rangle = 3(m_e a_0/m_n) b_{ne}$, where m_e and m_n are the masses of the electron and neutron, and a_0 is the Bohr radius. Numerically, $\langle r_n^2 \rangle = 86.34\, b_{ne}$, if we use a_0 for a nucleus with infinite mass.

VALUE (fm^2)	*DOCUMENT ID*	*COMMENT*
−0.1161±0.0022 OUR AVERAGE	Error includes scale factor of 1.3. See the ideogram below.	
−0.115 ±0.002 ±0.003	KOPECKY 97	$n e$ scattering (Pb)
−0.124 ±0.003 ±0.005	KOPECKY 97	$n e$ scattering (Bi)
−0.114 ±0.003	KOESTER 95	$n e$ scattering (Pb, Bi)
−0.134 ±0.009	ALEKSANDR...86	$n e$ scattering (Bi)
−0.115 ±0.003	[13] KROHN 73	$n e$ scattering (Ne, Ar, Kr, Xe)
• • • We do not use the following data for averages, fits, limits, etc. • • •		
−0.113 ±0.003 ±0.004	KOPECKY 95	$n e$ scattering (Pb)
−0.114 ±0.003	KOESTER 86	$n e$ scattering (Pb, Bi)
−0.118 ±0.002	KOESTER 76	$n e$ scattering (Pb)
−0.120 ±0.002	KOESTER 76	$n e$ scattering (Bi)
−0.116 ±0.003	KROHN 66	$n e$ scattering (Ne, Ar, Kr, Xe)

[13] This value is as corrected by KOESTER 76.



n mean-square charge radius

n ELECTRIC POLARIZABILITY α_n

Following is the electric polarizability α_n defined in terms of the induced electric dipole moment by $\mathbf{D} = 4\pi\epsilon_0 \alpha_n \mathbf{E}$. For a review, see SCHMIEDMAYER 89.

VALUE (10^{-4} fm^3)	*DOCUMENT ID*	*TECN*	*COMMENT*
11.6± 1.5 OUR AVERAGE			
$12.5 \pm 1.8^{+1.6}_{-1.3}$	[14] KOSSERT 03	CNTR	$\gamma d \to \gamma p n$
8.8± 2.4±3.0	[15] LUNDIN 03	CNTR	$\gamma d \to \gamma d$
12.0± 1.5±2.0	SCHMIEDM... 91	CNTR	n Pb transmission
$10.7^{+3.3}_{-10.7}$	ROSE 90B	CNTR	$\gamma d \to \gamma n p$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
13.6	[16] KOLB 00	CNTR	$\gamma d \to \gamma n p$
0.0± 5.0	[17] KOESTER 95	CNTR	n Pb, n Bi transmission
$11.7^{+4.3}_{-11.7}$	ROSE 90	CNTR	See ROSE 90B
8 ±10	KOESTER 88	CNTR	n Pb, n Bi transmission
12 ±10	SCHMIEDM... 88	CNTR	n Pb, n C transmission

[14] KOSSERT 03 gets $\alpha_n - \beta_n = (9.8 \pm 3.6^{+2.1}_{-1.1} \pm 2.2) \times 10^{-4}$ fm^3, and uses $\alpha_n + \beta_n = (15.2 \pm 0.5) \times 10^{-4}$ fm^3 from OLMOSDELEON 01. Thus the errors on α_n and β_n are anti-correlated.

[15] LUNDIN 03 measures $\alpha_N - \beta_N = (6.4 \pm 2.4) \times 10^{-4}$ fm^3 and uses accurate values for α_p and α_p and a precise sum-rule result for $\alpha_n + \beta_n$. The second error is a model uncertainty, and errors on α_n and β_n are anticorrelated.

[16] KOLB 00 obtains this value with a lower limit of 7.6×10^{-4} fm^3 but no upper limit from this experiment alone. Combined with results of ROSE 90, the 1-σ range is $(7.6\text{–}14.0) \times 10^{-4}$ fm^3.

[17] KOESTER 95 uses natural Pb and the isotopes 208, 207, and 206. See this paper for a discussion of methods used by various groups to extract α_n from data.

n MAGNETIC POLARIZABILITY β_n

VALUE (10^{-4} fm^3)	*DOCUMENT ID*	*TECN*	*COMMENT*
3.7±2.0 OUR AVERAGE			
$2.7 \pm 1.8^{+1.3}_{-1.6}$	[18] KOSSERT 03	CNTR	$\gamma d \to \gamma p n$
6.5±2.4±3.0	[19] LUNDIN 03	CNTR	$\gamma d \to \gamma d$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1.6	[20] KOLB 00	CNTR	$\gamma d \to \gamma n p$

[18] KOSSERT 03 gets $\alpha_n - \beta_n = (9.8 \pm 3.6^{+2.1}_{-1.1} \pm 2.2) \times 10^{-4}$ fm^3, and uses $\alpha_n + \beta_n = (15.2 \pm 0.5) \times 10^{-4}$ fm^3 from OLMOSDELEON 01. Thus the errors on α_n and β_n are anti-correlated.

[19] LUNDIN 03 measures $\alpha_N - \beta_N = (6.4 \pm 2.4) \times 10^{-4}$ fm^3 and uses accurate values for α_p and α_p and a precise sum-rule result for $\alpha_n + \beta_n$. The second error is a model uncertainty, and errors on α_n and β_n are anticorrelated.

[20] KOLB 00 obtains this value with an upper limit of 7.6×10^{-4} fm^3 but no lower limit from this experiment alone. Combined with results of ROSE 90, the 1-σ range is $(1.2\text{–}7.6) \times 10^{-4}$ fm^3.